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STATE OF CALIFORNIA
The Resources Agency

Department of Water Resources

BULLETIN No. 74-7

Water Well Standards

ARROYO GRANDE BASIN
SAN LUIS OBISPO COUNTY

JULY 1971

NORMAN B. LIVERMORE, JR.	RONALD REAGAN	WILLIAM R. GIANELLI
Secretary for Resources	*Governor*	*Director*
The Resources Agency	State of California	Department of Water Resources

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AUTHORIZATION

The Water Well Standards Program under which this report was prepared is authorized by Section 231 of the Water Code, State of California which reads:

> "231. The department, either independently or in cooperation with any person or any county, state, federal or other agency, shall investigate and survey conditions of damage to quality of underground waters, which conditions are or may be caused by improperly constructed, abandoned or defective wells through the interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate regional water quality control board its recommendations for minimum standards of well construction in any particular locality in which it deems regulation necessary to protection of quality of underground water, and shall report to the Legislature from time to time, its recommendations for proper sealing of abandoned wells."

In 1967, the Legislature established a procedure for implementing standards developed under Section 231 by enacting Chapter 323, Statutes of 1967, which added Sections 13800 through 13806 to the Water Code. In Section 13800, the Department of Water Resources' reporting responsibility is enlarged upon:

> "13800. The department, after such studies and investigations pursuant to Section 231 as it finds necessary, on determining that water well and cathodic protection well construction, maintenance, abandonment, and destruction standards are needed in an area to protect the quality of water used or which may be used for any beneficial use, shall so report to the appropriate regional water quality control board and to the State Department of Public Health. The report shall contain such recommended standards for water well and cathodic protection well construction, maintenance, abandonment, and destruction as, in the department's opinion, are necessary to protect the quality of any affected water."

FOREWORD

Bulletin No. 74-7 recommends standards for the construction and destruction of water wells in the Arroyo Grande Basin, San Luis Obispo County. It is one of a series dealing with the problem of preventing the deterioration of ground water quality from poorly constructed or improperly destroyed wells.

The standards herein are based on the particular subsurface geology, hydrology, and water quality conditions of the Arroyo Grande Basin and are to be employed in connection with Bulletin No. 74, "Water Well Standards: State of California".

For their assistance in this investigation, grateful acknowledgment is made to the San Luis Obispo County's Health Department and Flood Control and Water Conservation District, as well as to various state agencies, cities, public and private organizations, and individuals.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California
June 29, 1971

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ABSTRACT

This Bulletin describes supplemental well-sealing standards to protect ground water quality in the Arroyo Grande Basin. / Based on geology and water quality, three zones requiring standards can be delineated. / In 1965, San Luis Obispo County adopted limited control of water well construction and destruction. / Applying only to domestic wells, it enacted an ordinance employing the standards in the preliminary edition of DWR Bulletin No. 74. / This Bulletin and Chapter II of Bulletin No. 74 amplify and develop those standards in order to minimize ground water impairment from improperly constructed, destroyed, or defective wells.

CHAPTER I. INTRODUCTION AND SUMMARY

During the past 20 years, considerable public and private concern has been expressed over the high nitrate concentrations in the ground water of the Arroyo Grande Basin of San Luis Obispo County, which lies within the Arroyo Grande hydrologic subarea (Figure 1).

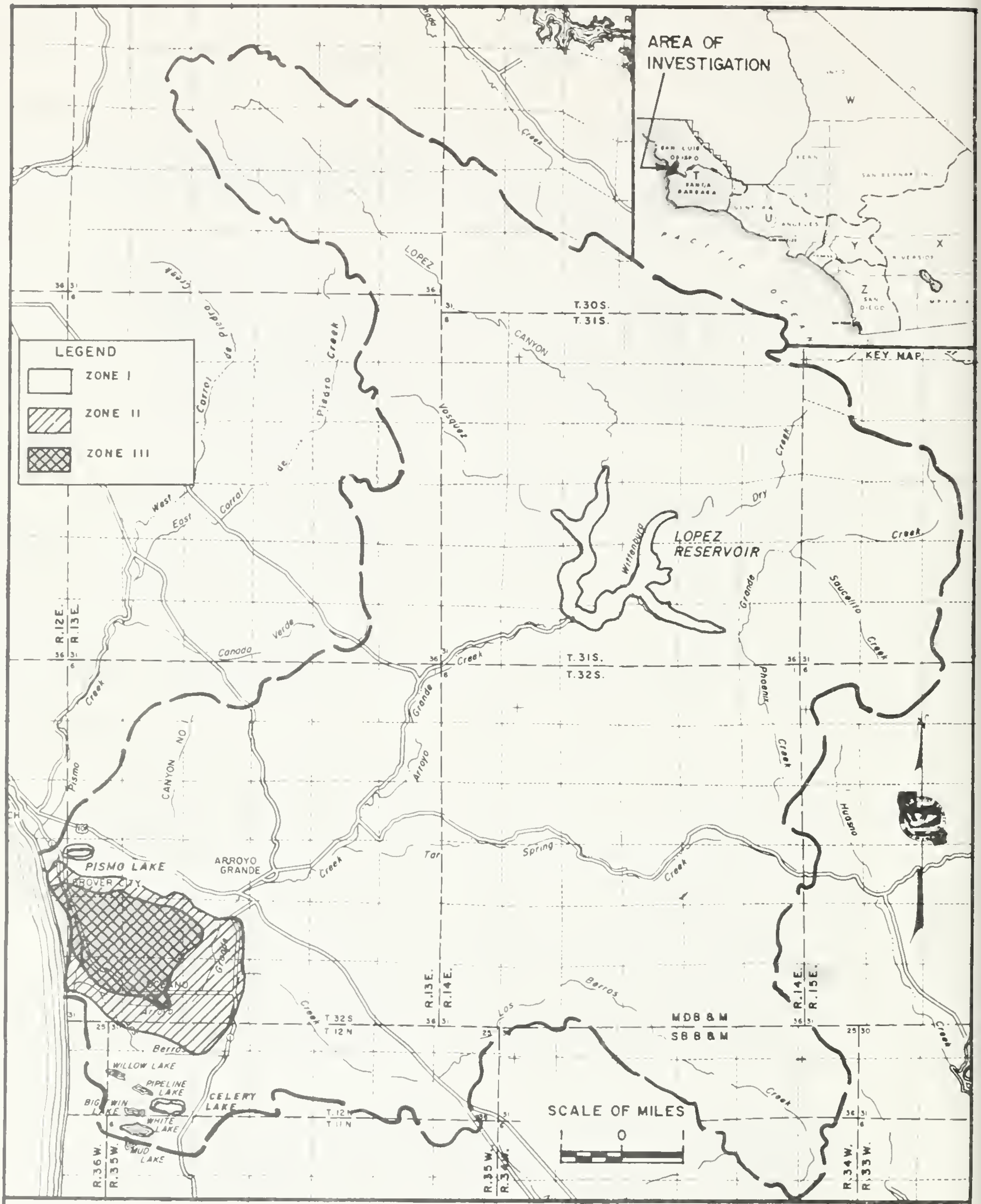
Ground water degradation by nitrate has generally coincided with increased water use and waste discharge in the Basin. In localized areas, irrigation return water, sewage, and other poor quality water have migrated downward into the water-bearing zones and have impaired the ground water for certain beneficial uses. One way this may have happened is through improperly constructed or destroyed wells.

Because the Arroyo Grande Basin's major supply is ground water, protection of its quality is of paramount importance to the development, prosperity, and well-being of the communities within it. However, since the construction of Lopez Reservoir, the municipal source of water for the Cities of Arroyo Grande and Grover City is from the Reservoir.

Investigations were conducted in the late 1950's and early 1960's to discover the source of the nitrate impairment in the Basin, define its extent, and then seek effective remedies (DWR 1962, UC Davis 1965).

As the outcome of those investigations, it was learned that the impairment was caused by (a) disposal of treated domestic wastes from the City of Arroyo Grande Sewage Treatment Plant; (b) individual domestic waste disposals from septic tanks; and (c) the agricultural application of nitrogenous fertilizers. The Department of Water Resources therefore recommended that: (a) "Rigid standards for the initial construction of water wells and the possible destruction or disuse of wells should be developed to protect the deeper ground water supplies from further impairment from the application of nitrogenous fertilizers and domestic sewage ...."; and UC Davis recommended: "....Irrigation wells should be encouraged to draw water from the shallow aquifers as a means of confining the nitrate cap to their extraction levels."

The first recommendation -- the establishment of water well standards -- was implemented by San Luis Obispo County's Ordinance Code Section 9-905, adopting the standards in the preliminary edition of DWR Bulletin No. 74, "Recommended Minimum Well Construction and Sealing Standards for Protection of Ground Water Quality, State of California", (1962). Adoption of the ordinance was prompted by a typhoid epidemic which occurred in Nipomo in 1964 as a result of pollution of well water with seepage from septic tank wastes. However, the ordinance applies only to domestic wells.



LOCATION MAP AND
Figure I - AREAS OF RECOMMENDED STANDARDS

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1971

The second recommendation -- encouraging users of irrigation wells to draw water from shallow aquifers -- was not implemented.

In June 1966, the City of Arroyo Grande Sewage Treatment Plant discontinued discharging sewage effluent on land. About 50 percent of the area is now served by sewerage facilities, with ocean disposal after treatment. Nevertheless, despite these measures to lessen nitrate impairment, it grew worse. In late 1968, the staff of the Central Coastal Regional Water Quality Control Board, local agencies, and concerned individuals decided on the following corrective measures: (1) reduce fertilization to optimum crop requirements; (2) improve irrigation practices; (3) prohibit the use of septic tanks; and (4) prescribe and implement water well standards.

At the Board's request, a study of agricultural practices to improve fertilization techniques and increase irrigation efficiency is being conducted by the San Luis Obispo County Farm Advisory Office with the University of California at Davis.

In 1969, the Board adopted Resolution No. 69-1, "Sewage Facilities and Septic Tanks in Urbanizing Areas in the Central Coastal Region". In essence, this established a policy requiring city and county governments to minimize the installation of septic tanks and leaching systems.

As a result of discussions between the Board and this Department, the Board passed Resolution No. 69-4 of June 13, 1969, requesting this Department to undertake a well standards investigation. The investigation was initiated in August 1969.

OBJECTIVE, SCOPE, AND CONDUCT OF THE INVESTIGATION

The objective of the investigation was the formulation of specific standards for constructing and destroying water wells in the Arroyo Grande Basin, supplementing those in DWR Bulletin No. 74. They would enable local agencies to enact regulatory legislation.

To set such standards, however, it was necessary to examine, analyze, and interpret the geologic, hydrologic, and quality data in the files of the Department, as well as those of other agencies and individuals.

It then became possible to (a) determine geologic conditions; (b) fix ground water elevations and the direction of ground water movement; (c) locate the sources of ground water replenishment; (d) define ground and surface water quality conditions; and (e) delineate areas of impairment requiring specific construction and sealing standards. To ascertain water quality conditions, mineral analyses from 1950 through 1969 were employed.

In 1970, field work was coordinated with other investigations and was limited to updating information concerning the distribution of surface and ground water.

This report also contains water quality information generated from a cooperative water resources study started in 1968 by this Department and San Luis Obispo County Flood Control and Water Conservation District (SLOCFCWCD).

AREA OF INVESTIGATION

The area of investigation is in the south coastal part of San Luis Obispo County, midway between the Cities of San Luis Obispo to the north and Santa Maria to the southeast (Figure 1). It is known as the Arroyo Grande hydrologic subarea (DWR, April 1964), which can be further divided into a nonwater-bearing hill and mountain area and a ground-water-bearing valley area. In this report, the valley is termed the "Arroyo Grande Basin", or "Basin", to distinguish it from the entire subarea, which comprises the neighboring hill and mountain areas.

The area is characterized by the rugged Santa Lucia Range on the northeast, its highest peak being High Mountain, 3,180 feet above sea level. Arroyo Grande Creek and its tributaries draining to the southwest have cut deep, narrow channels into the lower flanks of the Range. The Creek has formed a broad valley through the San Luis Obispo Hills. This valley is about 3/4 of a mile wide at its mouth, near the City of Arroyo Grande and broadens into a 10-square-mile coastal plain. The Creek empties into the Pacific Ocean near Oceano.

The climate of the area is characterized by warm, dry summers and cool, wet winters. Dense coastal fogs are common throughout the year. During winter and summer, temperatures average 53°F and 62°F, respectively, the year-round average being about 58°F. However, during winter, temperatures rarely drop below freezing. Precipitation occurs chiefly as rain, although at higher altitudes light snowfall sometimes occurs. Most of the precipitation takes place from October through April. Average seasonal precipitation increases northeastward, from about 15 inches on the southwest to about 35 inches at Lopez Mountain.

Because of rapid population growth, urban and suburban land and water use are expanding (Table 1). From 1959 through 1968, land devoted to urban and suburban use expanded

TABLE 1

LAND USE AND APPLIED WATER
ARROYO GRANDE HYDROLOGIC SUBAREA

Category	Land use (in acres)		Applied water (in acre-feet)	
	1959	1968	1959	1968
Net urban and suburban	1,590	2,110	3,140	3,950
Net irrigated agriculture	3,480	3,420	9,460	9,550
TOTAL	5,070	5,530	12,600	13,500

(The 1959 figures were obtained, in part, from Appendix B of DWR Bulletin No. 103, "San Luis Obispo and Santa Barbara Counties Land and Water Use Survey, 1959."

(The 1968 figures were obtained, in part, from data compiled for the "San Luis Obispo and Santa Barbara Counties Land and Water Use Report," April 11, 1969.)

32 percent and urban water use, 26 percent. During that period, land use for net irrigated agriculture has decreased slightly, while applied water has increased 90 acre-feet (Table 1).

Population is growing steadily. From 1960 through 1968, the City of Arroyo Grande has increased from about 3,300 to 7,600; Grover City, from about 5,200 to about 6,000; and Oceano, from about 1,300 to 1,800 (State Department of Finance, 1966 and State Division of Highways, 1969).

San Luis Obispo County Flood Control and Water Conservation District has contracted for a maximum entitlement of 25,000 acre-feet a year from the State Water Project, initial delivery scheduled for 1980. Because of the expanding urban development in the County's south coastal area, the demand for imported water is likely to be in the order of 10,000 acre-feet by 1990 (SLOCFCWCD 1965).

FINDINGS

1. The Arroyo Grande Basin consists of a multiple aquifer system.

2. Recent and upper Pleistocene alluvium is its primary water-bearing source; its secondary water-bearing source is the Paso Robles formation of lower Pleistocene and upper Pliocene age.

3. Its ground water is replenished principally by percolation of streamflow, precipitation, excess irrigation water, and subsurface inflow.

4. Ground water for irrigation, industrial, and domestic purposes, is extracted chiefly from the alluvium along Arroyo Grande Creek, where it is generally unconfined.

5. The quality of the ground water occurring at shallow depths generally is of poorer quality than that in the deeper aquifers.

6. The mineral quality of waste water is inferior to water from the deeper aquifers.

CONCLUSIONS

1. Improperly constructed and destroyed wells or defective wells provide a means for poor quality surface and shallow ground water to invade aquifers containing good water.

2. Water well construction, maintenance, abandonment, and destruction standards are needed in the Basin, and by copy of this report we are so advising the California Regional Quality Control Board, Central Coast Region, and the California Department of Public Health, pursuant to Section 13800 of the State Water Code.

3. The general standards in Chapter II of DWR Bulletin No. 74, "Water Well Standards: State of California", are sufficient to protect the quality of the existing ground water in Zone I. However, in Zones II and III of the Coastal Plain, specific standards are necessary to prevent the percolation of poor quality surface or shallow ground water from impairing the deeper, good quality ground water.

RECOMMENDATIONS

It is recommended that water well standards be established in Arroyo Grande Basin and that the general standards presented in Chapter II of the DWR Bulletin No. 74, "Water Well Standards: State of California", February 1968, together with the specific standards presented in this report on pages 15 through 19, form the basis for those standards.

CHAPTER II. WELL STANDARDS

Standards are established to prevent impairment of water quality resulting from (a) improperly constructed wells; (b) improperly destroyed wells; or (c) defective wells. They apply also to those wells in use requiring modification and to those to be destroyed.

The standards presented in Chapter II of DWR Bulletin No. 74 should be used in well construction or destruction in the Arroyo Grande subarea. However, in some parts of the Basin, ground water conditions necessitate supplementing statewide well standards. For example, because the deeper aquifers usually contain better quality water than the shallower, measures must be taken to seal off wells in the shallower aquifers to prevent the impaired water from invading the deeper.

WELL CONSTRUCTION STANDARDS

Water well construction data and related mineral analyses made possible the correlation of the ground water samples with depth and thus made possible the establishment of sealing zones based on the subsurface geology in the southwest portion of the Basin (See Chapters III and IV).

Because of the characteristics of its ground water occurrence, its geologic structure, and its water quality conditions, the Arroyo Grande subarea has been divided into three zones (Figure 1).

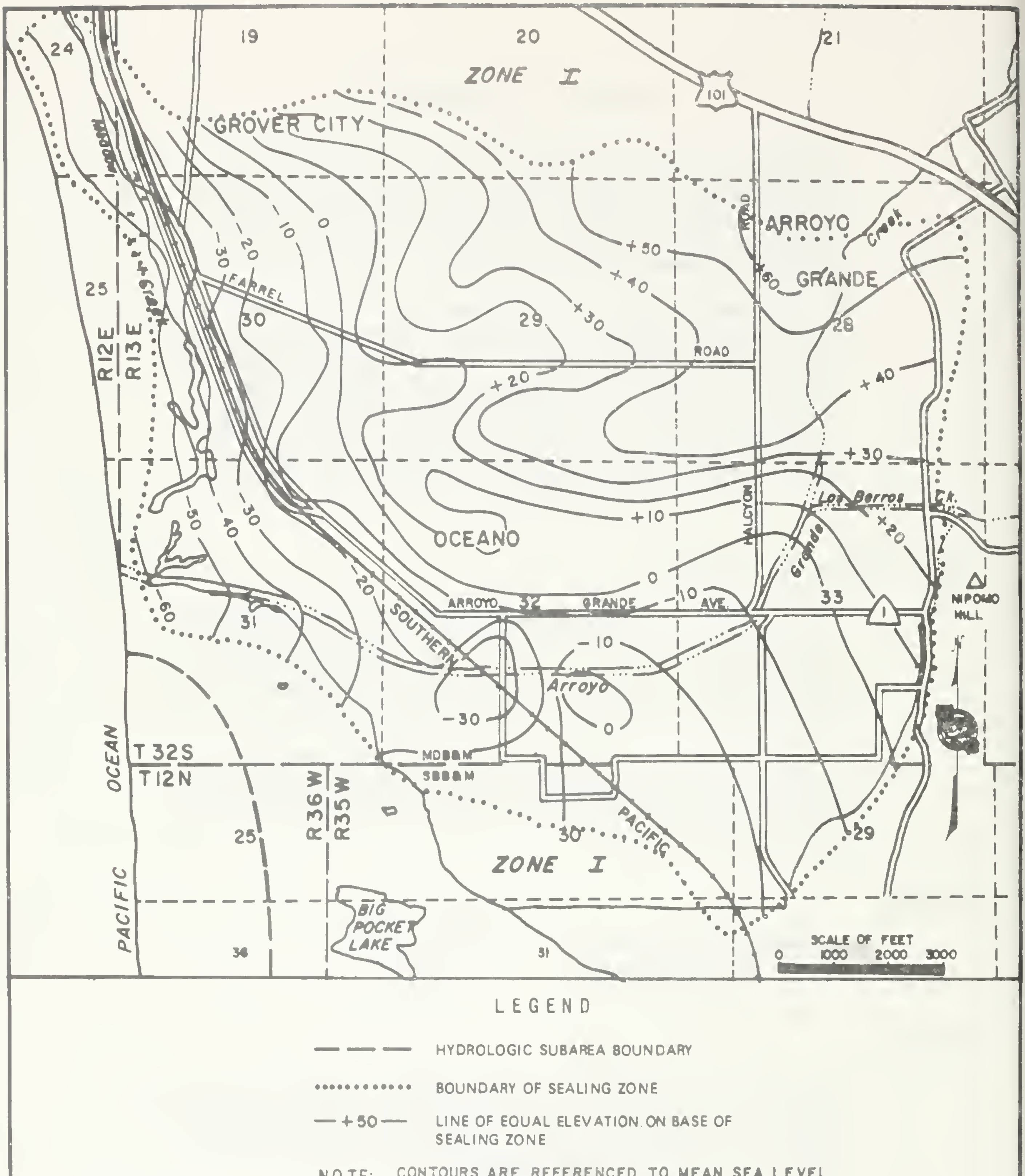
Zone I.

The general well standards from DWR Bulletin No. 74 apply to all the study area.

Zone II.

The vertical percolation of poor quality surface and shallow ground water can be retarded in wells by sealing off the predominantly clay member underlying the sand dune deposits or the predominantly clay member occurring within the alluvial deposits of Arroyo Grande and Los Berros Creeks.

Except for several well logs indicating the predominant presence of sand in the upper 100 feet of sediments, the clay members constitute a fairly continuous sealing horizon. Elevations of the base of the clay members are shown on Figure 2.



LEGEND

HYDROLOGIC SUBAREA BOUNDARY

BOUNDARY OF SEALING ZONE

—+50— LINE OF EQUAL ELEVATION ON BASE OF SEALING ZONE

NOTE: CONTOURS ARE REFERENCED TO MEAN SEA LEVEL U. S. GEOLOGICAL SURVEY DATUM.

Figure 2 - LINES OF EQUAL ELEVATIONS ON BASE OF SEALING ZONE II

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1971

Recommended Standards. In addition to the requirements described in the statewide standards, the annular space in all wells in Zone II shall be sealed from the surface to the base of the clay members, as shown on Figure 2.

Although in some locations in Zone II the vertical sealing increment is less than 50 feet, the annular space in municipal wells from the surface to a depth of at least 50 feet will have to be sealed for public health protection.

Wells that penetrate water-bearing zones below the elevations shown on Figure 3 require additional sealing, as indicated for Zone III.

Zone III.

The Basin has multiple aquifers separated by fine-grained members of varying permeability, horizontally and vertically. As in Zone II, well logs indicate that, in some areas, wells penetrate sand and gravel predominantly. However, the clay member underlying an A aquifer is believed to be fairly continuous.

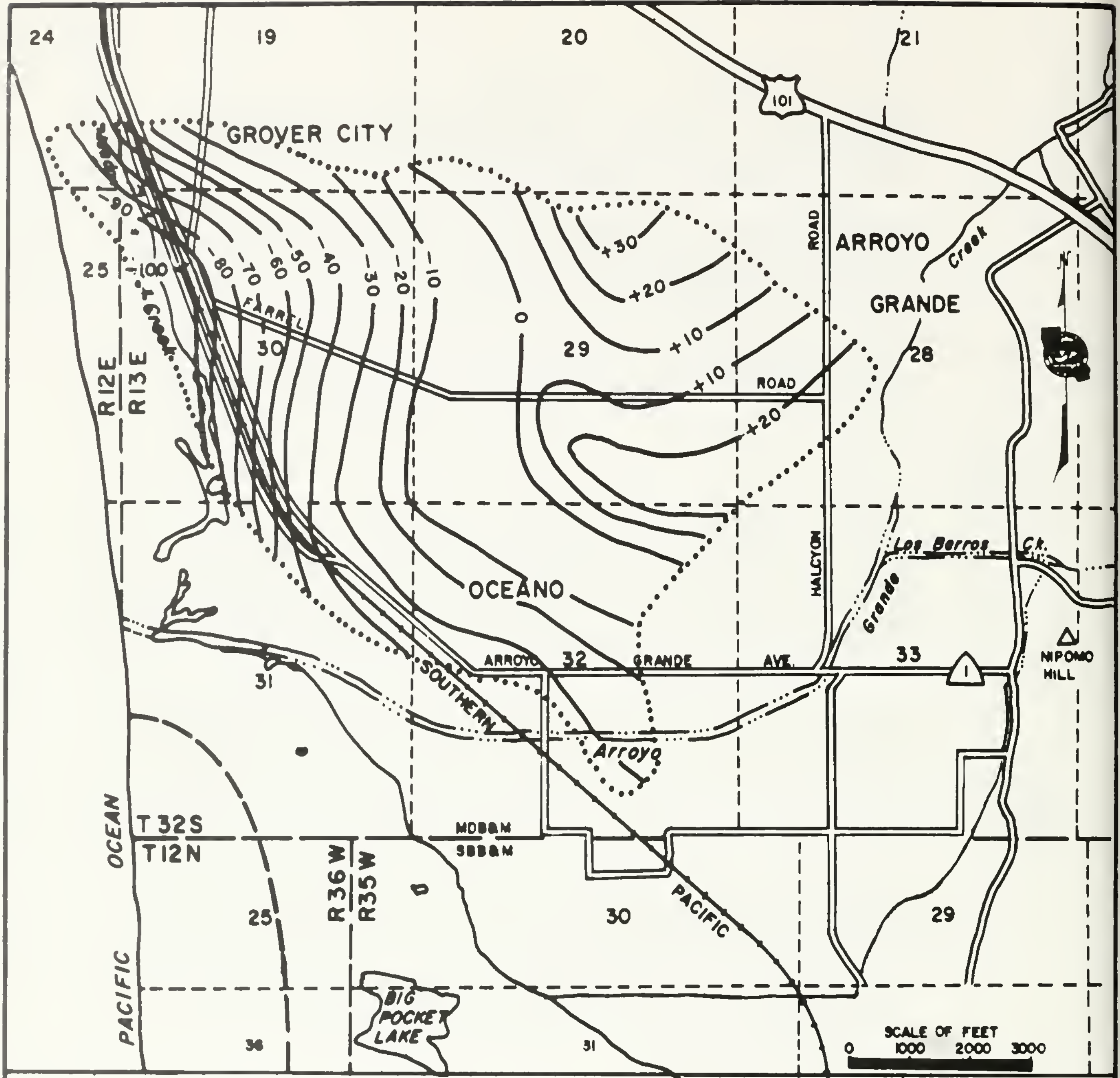
The aquifers to be protected in Zone III are those underlying the A aquifer of the Paso Robles formation. In some portions of the Basin, where the A aquifer consists of multiple aquifers, the sealing should be below the first aquifer. Elevations of the top of the clay members underlying the A aquifer or the upper aquifer of the A aquifer are shown on Figure 3.

Recommended Standards. Wells that do not penetrate elevations shown on Figure 3 shall comply with the requirements of Zone II. In addition to the requirements for Zone II, the annular seal in all wells that penetrate water-bearing zones below the elevations shown on Figure 3 shall extend 20 feet below those elevations. Moreover, the casing of all wells shall not be perforated above them.

Because many of the wells in the western half of Zone III are less than 100 feet deep, the base of the sealing horizon for this portion of Zone III is based on the extrapolation of meager data. In this portion, the sealing horizons in the construction of a new well should be based on the well log, using the elevations shown on Figure 3 as a guide.

WELL MAINTENANCE STANDARDS

To protect the quality of the affected water, the annular space in all zones of the Basin's present wells -- whether they are idle or in



LEGEND

HYDROLOGIC SUBAREA BOUNDARY

BOUNDARY OF SEALING ZONE

—+50— LINE OF EQUAL ELEVATION ON TOP OF SEALING ZONE

NOTE: CONTOURS ARE REFERENCED TO MEAN SEA LEVEL U.S. GEOLOGICAL SURVEY DATUM

Figure 3 - LINES OF EQUAL ELEVATIONS ON TOP OF SEALING ZONE III

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1971

use -- should be maintained according to the standards prescribed for construction of new wells, if the wells are not sealed already.

WELL ABANDONMENT AND DESTRUCTION STANDARDS[1/]

To protect the quality of the affected water, a well not in use for one year shall be destroyed or maintained as defined under Section 21, DWR Bulletin No. 74.

Those wells that no longer serve a useful purpose or have fallen into such a state of disuse and disrepair that they may become a means for degradation to ground water quality should be destroyed in a manner that will prevent impairment.

In portions of the study area, supplemental standards, in addition to those in DWR Bulletin No. 74, are needed to protect the quality of ground water when a well is destroyed. Such standards are for sealing off water of impaired quality.

Zone I.

Wells in Zone I should be destroyed according to the standards in DWR Bulletin No. 74.

Zone II.

In Zone II, all wells to be destroyed shall be filled and sealed with impervious sealing material from the ground surface to the elevations shown on Figure 2. The remainder of the well may be filled with inert filler material.

Zone III.

In addition to the requirements in Zone II, wells to be destroyed shall be filled and sealed with a 20-foot-thick impervious sealing material extending upward from 20 feet below those elevations shown on Figure 3. The remainder of the well shall be filled with inert filler material.

1/Before any water well is destroyed, the San Luis Obispo County Flood Control and Water Conservation District or the State Department of Water Resources should be consulted. Use of such wells for monitoring of ground water conditions will be reviewed.

TABLE 2* (Revised)

GENERALIZED STRATIGRAPHIC COLUMN OF WATER-BEARING FORMATIONS**

AGE	Formation (Maximum thickness in feet)	Aquifer (Maximum thickness in feet)	Maximum depth to base (in feet)	Generalized lithology and areal extent	Hydrogeologic features Water-bearing properties, use, maximum well yields, and specific capacity (SC)
RECENT	Dune sand—Qsr (190)	—	190	Fine to medium sand. Unconsolidated. Extensive dune belt along coast.	High permeability. Largely unsaturated. Unconfined. Transmits precipitation to Qal. Not tapped by wells.
	Alluvium—Qal Arroyo Grande Creek (130)	Upper Zone (50)	50	Fine to coarse sand and gravel with sandy silt and clay. Grades to sandy silt and clay south and east of streambed. Unconsolidated.	Moderate to high permeability. Unconfined. Tapped by domestic wells near coast. 70 gpm. SC 14 gpm/ft.
		Lower Zone (80)	130	Medium to coarse sand, gravel, and locally cobbles with sandy silt and clay. Unconsolidated.	High permeability. Confined to semiconfined (upstream). Principal aquifer of Arroyo Grande Plain. Tapped by large irrigation wells. 1700 gpm. SC 50 gpm/ft.
	Alluvium—Qal Los Berros Creek (100)	Undifferentiated (100)	100	Fine to coarse sand and gravel with sandy silt and clay. Unconsolidated.	Moderate to high permeability. Unconfined to semiconfined. Tapped by a few domestic wells.
UPPER PLEISTOCENE	Terrace Deposits —Qt (50)	—	50	Fine to coarse sand with gravel and sandy to gravelly silt. Unconsolidated. Limited to a small area northwest of the City of Grover City	Low to moderate permeability. Largely unsaturated. Unconfined.
	Older Dune Sand —Qso			Fine to medium sand. Unconsolidated. Limited to mesas.	Moderate permeability. Largely unsaturated. Unconfined. Transmits precipitation and locally return irrigation water and sewage to underlying TQp. Tapped by sand points and domestic wells near Black Lake Slough on Nipomo Mesa.
	Tri-Cities Mesa (40)	—	40		
	Nipomo Mesa (150)	—	150		
LOWER PLEISTOCENE — PLIOCENE	Paso Robles Formation —TQp (780)	A to E Zones	850	Fine to coarse sand and gravel, silty to clayey sand and gravel, and fine to medium silty sand. Unconsolidated. Two to five aquifers designated from top to bottom as the A to E Zones. Aquifers separated by silt and clay confining beds near coast, merged inland.	Moderate to high permeability. Confined at coast and below alluvial plains. Confined to unconfined beneath mesa and along flanks of foothills. Major aquifer system. Tapped by large municipal, industrial and irrigation wells, as well as numerous domestic wells.
PLIOCENE	Careaga Sand —Tpc (740)	Undifferentiated	1,600	Fine to coarse sand with gravel, fine to medium sand, and silty sand. Unconsolidated to well cemented, calcareous. Two to three aquifers, undifferentiated. Aquifers separated by relatively continuous silt and clay confining beds. Underlies the basin.	Low to moderate permeability. Confined. Tapped by a few deep wells multiperforated in overlying aquifers. Potentially an important water supply.
	Pismo Formation —Tpp Fresh water-bearing sandstone members (600)	Undifferentiated	600	Fine to coarse sand with interbeds of hard calcareous sandstone. Unconsolidated. Upper portion believed equivalent to Careaga Sand. Limited to the San Luis Hills.	Low to moderate permeability. Unconfined. Tapped by a few domestic wells. Potentially an important water supply.

*Figure 3 of Bulletin No. 63-3.
**Arroyo Grande Basin

CHAPTER III. GEOHYDROLOGY

The nature and extent of the Arroyo Grande Basin and the distribution and sequence of its water-bearing materials were determined by geologic studies (DWR, 1970). The amount of replenishment of the ground water basin and the manner and extent of its discharge of ground water were determined by hydrologic studies (DWR, 1958 and 1970).

GEOLOGY

Deposition of the water-bearing formations is largely the result of geologic events since late Pliocene time. The relationship of the water-bearing zones and the areal relationship and description of the geologic formations are depicted on Figure 4 and in Table 2.

Water-Bearing Formations

The water-bearing sediments, from youngest to oldest, consist of Recent sand dunes, alluvium, terrace deposits, older sand dunes, Paso Robles formation, Careaga sand, and Pismo formation (locally water-bearing). These include all permeable deposits capable of storing water (Figure 4 and Table 2). In some cases, however, they lie above the regional water table and do not produce any water.

In areas where sands and gravels underlie the Basin's surface, deep percolation of precipitation, surface runoff, and irrigation return to the water table are unrestricted. In addition, in areas where shallow layers of low permeability are present, small quantities of water percolate to the water table via lenses of sand and gravel.

The fine-grained materials, particularly silts and clays, have only minute spaces between the particles and consequently resist water movement. Layers of these materials between aquifers that do not furnish enough water to supply wells are called aquicludes or aquitards; they reduce the rate of vertical movement of ground water from the ground surface and between aquifers. Hence, the location of aquicludes, or aquitards, has a direct bearing on the determination of water well standards.

Recent Sand Dunes. This formation usually lies above the freshwater table. It may contain sea water where it is in contact with the ocean, and it yields no usable fresh water. Recent sand dune deposits consist of fine- to medium-sized beach sands and extend inland for about 2 miles. They are not tapped by wells.

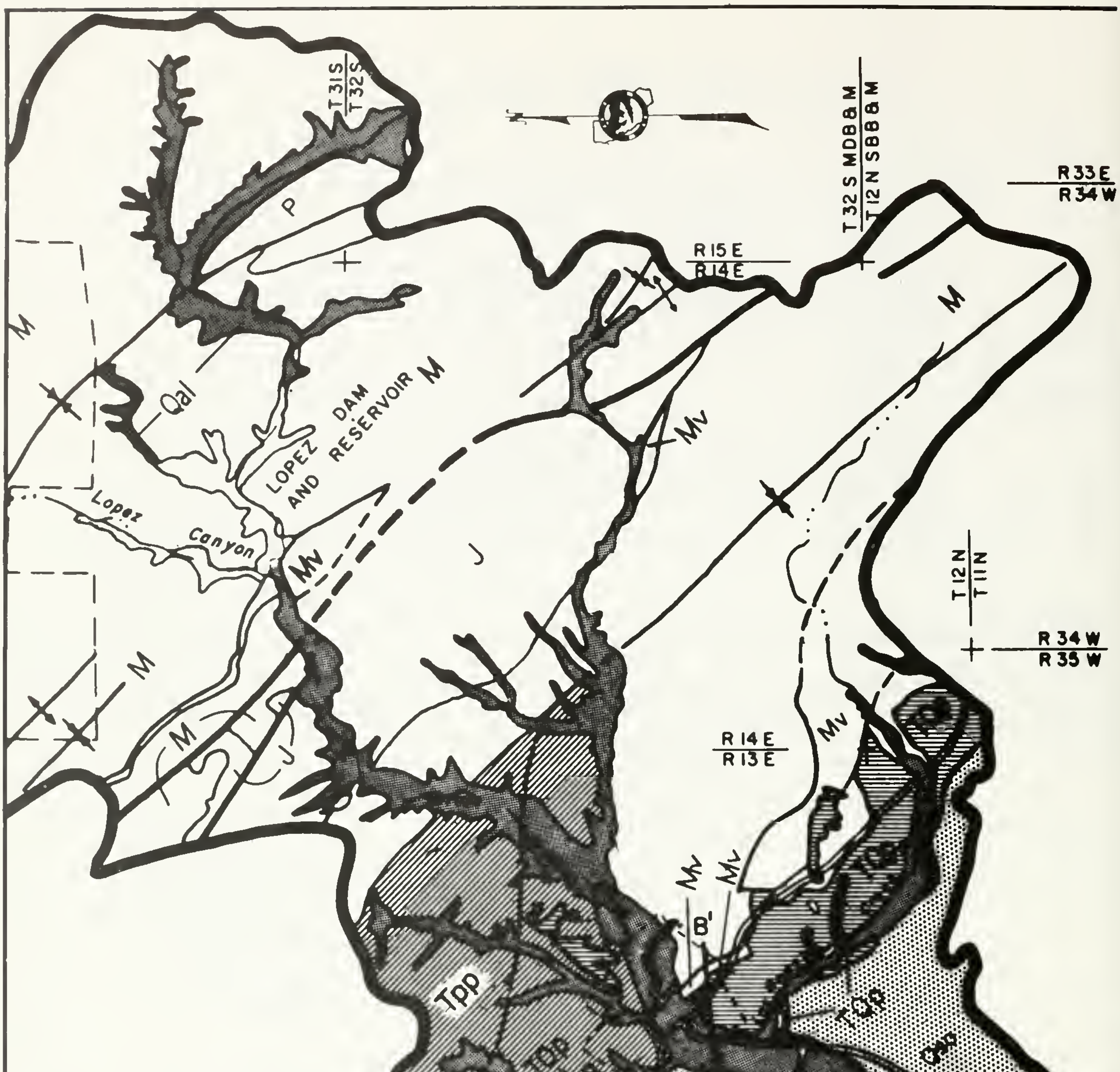


Figure 4 — AREAL GEOLOGY

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1971

LEGEND

SEDIMENTARY FORMATIONS

WATER-BEARING

QUATERNARY
- RECENT
  - Qsr — RECENT SAND DUNES
  - Qal — ALLUVIUM
    SAND, GRAVEL, AND CLAY
- UPPER PLEISTOCENE
  - Qso — OLDER SAND DUNES
  - Qt — TERRACE DEPOSITS AND OLDER ALLUVIUM
    MARINE AND CONTINENTAL SAND, GRAVEL, AND CLAY
  - TQp — PASO ROBLES FORMATION
    CONTINENTAL SAND, GRAVEL, SILT, CLAY, FRESH WATER LIMESTONE AND TUFF (UPPER PASO ROBLES FORMATION IN PASO ROBLES BASIN)

TERTIARY
- PLIOCENE
  - Tpp — PISMO FORMATION
    MARINE AND CONTINENTAL SANDSTONE, CONGLOMERATE AND SHALE
    (LOCALLY WATER-BEARING)

NONWATER-BEARING

TERTIARY
- PLIOCENE
  - P — MARINE AND CONTINENTAL SANDSTONE, CONGLOMERATE AND SHALE
- MIOCENE
  - M — MARINE AND CONTINENTAL SANDSTONE, SHALE, AND CONGLOMERATE
- OLIGOCENE
  - Φ — CONTINENTAL SANDSTONE, CONGLOMERATE, AND SHALE

CRETACEOUS
  - K — MARINE SANDSTONE, CONGLOMERATE, AND SHALE

JURASSIC
  - J — SEDIMENTARY AND IGNEOUS ROCKS

IGNEOUS ROCKS

TERTIARY
- MIOCENE
  - Mv — VOLCANICS
    BASALTIC, ANDESITIC, AND RHYOLITIC ROCKS

A —— A' LINE OF GEOLOGIC SECTION (REFER TO PLATE 2A, D.W.R. BULLETIN NO. 63-3)

CONTACT, DASHED WHERE INFERRED

ANTICLINE — DASHED WHERE APPROXIMATELY LOCATED

SYNCLINE — DASHED WHERE APPROXIMATELY LOCATED

FAULT, DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED

NOTE: THIS MAP IS A PORTION OF PLATE 7-B, DWR BULLETIN NO. 18 "SAN LUIS OBISPO COUNTY INVESTIGATION," EXCEPT FOR MINOR MODIFICATIONS OF HIGHWAYS, A CHANGE IN THE MIOCENE UNIT, AND ADDITION OF Qt AND LOPEZ RESERVOIR.

Recent and Upper Pleistocene Alluvium. These formations form the principal water-bearing unit in the area. Wells in the lower zone of alluvium of Arroyo Grande Creek, where estimated permeability ranges from 2,300 to 3,000 gallons per day per square foot (gpd/sq.ft.), yield as much as 1,700 gallons per minute (gpm). This lower zone of sand and gravel, with clay interbeds, reaches a maximum thickness of 80 feet near the coast. An upper zone of finer-grained material, usually less than 50 feet thick, overlies the coarse lower zone. The upper zone yields water at a lesser rate than the lower.

Terrace Deposits. This formation of upper Pleistocene age usually lies above the water table and transmits water to underlying sediments or to the ocean. When saturated, however, it readily yields water to wells. It covers a limited area, consists of silt, sand, and gravel; and is as much as 50 feet thick. These deposits have undergone only a limited development.

Older Sand Dunes. This formation of upper Pleistocene age has high infiltration and percolation rates and forms significant areas of recharge of rainfall. The formation does not yield much water because (1) it is largely unsaturated; and (2) because sand enters wells during periods of high pumping. Water that is not pumped percolates to the deeper water-bearing zones and moves laterally. These dunes overlie about 5 square miles of the Basin.

Paso Robles Formation. This formation of lower Pleistocene age ranks second only to alluvium as a ground water producer. Wells yield up to 2,500 gpm. The formation consists of sand, gravel, silt, and clay, with permeability ranging from 500 to 1,700 gpd/sq.ft. (DWR, 1958). Although it surfaces in comparatively small areas, it underlies large parts of alluvium and older sand dunes, thus forming a major aquifer. The Paso Robles formation contains five water-bearing zones - A through E - separated by clay (Table 2). As the formation approaches the foothills, the aquifers merge and thin out.

Careaga Sand. This formation of Pliocene age, predominantly of marine origin, attains a thickness of as much as 740 feet, and has a low to moderate permeability - about 70 gpd/sq.ft. It wholly underlies the Paso Robles formation, where it forms a minor aquifer. A few deep multiperforated wells tap this formation. It is potentially an important water supply.

Pismo Formation. This formation of lower to upper Pliocene age, outcrops northeast of U. S. Highway 101, extending eastward from Arroyo Grande Creek to west of Pismo Creek. It is locally water-bearing; the water-bearing portion is composed of sand similar to Careaga sand and ranges from

70 to 600 feet thick with permeabilities of more than 100 gpd/sq.ft. (DWR, 1970). This formation, which is potentially an important water supply, has undergone only limited development.

Nonwater-Bearing Formations

Consolidated rocks occasionally yield a little fresh water to wells and springs from fractures and joints, but are considered in this study as nonwater-bearing when they yield less than 25 gpm. They consist of the Monterey and Vaqueros (marine) formations of Miocene age, associated volcanics, and Cretaceous and Jurassic rocks.

HYDROLOGY

The ground water is replenished principally by percolation of streamflow and precipitation, plus some excess irrigation water and subsurface inflow from essentially nonwater-bearing areas. Ground water is diminished, however, by subsurface outflow, pumping, evapotranspiration, and export. About half the effluent resulting from municipal use of water is discharged to the ocean via the outfall sewerline completed in 1966.

Runoff from Lopez and upper Arroyo Grande Creeks is controlled by Lopez Reservoir, which was completed in January 1969 by SLOCFCWCD. Its capacity is 52,000 acre-feet, with an estimated yield of 6,230 acre-feet per year. It was filled as a result of the extremely high runoff in January and February 1969. Impoundment of surface water regulates the peak flow, resulting in longer periods of lower flow.

A recently completed distribution system will provide Lopez Reservoir water for the Pismo, Nipomo Mesa, San Luis Obispo Creek, and Port San Luis hydrologic subareas. As of June 1970, the Cities of Pismo and Grover City each accept 800 acre-feet annually and the City of Arroyo Grande accepts about 1,000 acre-feet and can accept up to 2,290 acre-feet annually.

Prior to the recent exportation of Lopez Reservoir water to the City of Pismo Beach, ground water exported from Arroyo Grande Basin to Pismo Beach served as that community's major source.

Precipitation

An isohyetal map, based on the 1935-36 to 1966-67 average seasonal precipitation, indicates that the most rainfall occurs on the western slopes of the Santa Lucia Mountains. As elevations rise, rainfall increases inland from 15 inches along the southern boundary to 50 inches near Lopez Mountain. About 75 percent occurs between December and April, less than 2 percent between June and October.

Surface Water

All creeks flow heavily during wet winters and some are dry during summer. Seasonal and monthly runoff varies with precipitation. However, the records of the Arroyo Grande Creek gaging station at Arroyo Grande indicate almost all-year flow; for the water years 1958-59 to 1965-66, it averaged 1,700 acre-feet per year and ranged from none at all to about 9,200 acre-feet. A station upstream, however, has recorded only seasonal flow.

Lakes and ponds in the Basin were formed by coastal sand dunes that blocked the seaward movement of surface water. Their surface areas fluctuate seasonally from 40 acres to a fraction of an acre. They are replenished by precipitation, surface runoff, irrigation return, and ground water seepage.

Ground Water

Ground water, used for irrigation, industrial, and domestic purposes, is found chiefly in alluvium along Arroyo Grande Creek, where it is generally unconfined (Table 2). Ground water -- confined and unconfined -- is also found in the following sediments: terrace deposits, older sand dunes, Paso Robles formation, Careaga sand, and Pismo formation.

Except in localized areas, where ground water flow is affected by local geohydrology, levels indicate that movement follows the land gradient. In the fall of 1969, the water level in a few wells less than a mile from the coast was drawn down about 2 feet below sea level. Farther inland, the level in some wells has been drawn down about 8 feet below sea level. In 1967, the level in Well No. 32/13E-29G1, about 2 miles inland, was 24.5 feet below sea level during pumping.

Onshore intrusion of sea water into ground water is not an immediate problem, although it is undoubtedly occurring offshore and may, in time, reach coastal wells (DWR Bulletin No. 63-3).

The estimated storage capacity of the Basin is 700,000 acre-feet; the storage capacity of the Basin above sea level is 40,000 acre-feet (DWR, 1958). The amount that can be extracted annually without causing a long-term change in ground water elevations is estimated to be 9,500 acre-feet. The maximum depth of the base of the fresh ground water at the coastline is about 700 feet below sea level (DWR, 1970).

CHAPTER IV. WATER QUALITY

In the study area, surface and ground water resources are used beneficially for recreation, for fish-and-wildlife propagation, and for domestic, municipal, industrial, and agricultural purposes. To establish well standards that will protect the quality of a particular body of ground water for these uses, the factors affecting the quality must be understood.

SURFACE WATER

The Arroyo Grande hydrologic subarea's surface water includes the perennial flow and storm runoff of Arroyo Grande Creek and its tributaries; shallow perennial lakes and marshes; a tidal estuary; lagoons; irrigation return water in drainage ditches; and Lopez Reservoir.

Analyses of the chemical quality of these waters which replenish the area's ground water are summarized in Table 3. Most flowing surface water is Class 1 and, to a lesser degree, Class 2 for irrigation, and a sample from Meadow Creek is Class 3, due to the high chloride (Cl) concentration.

Water from Arroyo Grande, Lopez, and Tar Springs Creeks generally meets U. S. Public Health Service (USPHS) Drinking Water Standards except for total dissolved solids concentrations that often exceed 500 milligrams per liter (mg/l)*, but are also often less than 700 mg/l. Water from Meadow, Canyon No. 1, and Los Berros Creeks has contained concentrations of TDS, chloride, sulfate (SO_4), nitrate (NO_3), and magnesium (Mg) in excess of the Drinking Water Standards limits.

Water in lakes and lagoons is Class 2 and 3 for irrigation. Also, such water does not meet the recommended USPHS Drinking Water Standards, because of sulfate and chloride concentrations above 250 mg/l, magnesium concentrations above 125 mg/l, and TDS concentrations above 500 mg/l.

GROUND WATER

Usually, the ground water quality in the Basin improves with depth (Table 4). Thus, ground water is generally Class 1 and 2 for irrigation, although occasionally it is Class 3 because of high electrical conductance and chloride concentrations.

For domestic use, ground water commonly contains mineral concentrations in excess of USPHS Standards, particularly TDS, and -- to a lesser degree and in descending order according

*Essentially equivalent to parts per million (ppm).

TABLE 3

SUMMARY OF SELECTED MINERAL CONSTITUENTS IN SURFACE WATER

Category	Number of analyses	Constituents in mg/l																		$EC \times 10^6$ at 25° C		
		Mg			SO_4			Cl			NO_3			B			TDS					
		Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
CREEKS																						
Arroyo Grande	17	12	43	85	62	159	263	13	32	53	0.0	3.0	14.0	0.00	0.06	0.12	265	605	825	355	850	1,165
Canyon No. 1	1		58			66			255			0.0			0.50			968			1,555	
Lopez	4	12	33	47	28	83	123	10	13	18	0.0	0.3	1.0	0.00	0.06	0.19	190	390	518	257	545	747
Los Berros	3	23	90	128	63	480	689	26	108	176	4.0	33.4	87.5	0.10	0.15	0.23	320	1,343	1,917	449	1,671	2,404
Meadow	1		97			305			556			8.7			0.06			1,809			2,919	
Tar Springs	2	27	42	57	55	136	220	30	36	42	0.0	3.0	6.0	0.10	0.25	0.40	297	488	678	412	736	1,060
LAKES																						
Big Twin	1		151			213			347			1.9			0.49			1,858			3,000	
Celery	1		148			996			218			6.2			0.44			2,327			2,821	
La Sage Riviera Golf Course	1		101			371			628			16.0			0.02			1,941			3.124	
Pismo	1		113			12			1,012			3.7			0.80			2,806			4,671	
White	3	89	108	138	148	378	657	279	481	676	2.5	25.8	37.2	0.60	1.00	1.40	1,913	2,178	2,400	2,612	3,145	3,623
LAGOON																						
Pismo	3	72	145	274	230	419	744	210	1,375	3,464	0.0	4.3	6.8	0.00	0.50	1.30	1,035	3,417	7,626	1,649	5,033	11,000

TABLE 4

MINERAL CONSTITUENTS FROM SELECTED WELLS
ARROYO GRANDE BASIN

WELL	Seal (feet)	Number of analyses	Constituents in mg/l												
			TDS			NO3			SO4			Cl			Mg.
			Min.	Avg.	Max.	Min.	Avg.	Max	Min	Avg.	Max.	Min.	Avg.	Max	Avg.
DEPTH 0'–50'															
32S/12E–24J1	—	1	—	408	—	—	98	—	—	56	—	—	64	—	17
–24K1	—	3	748	1,313	1,877	0	4	8	96	149	192	107	420	603	68
–24R1	0–30*	4	567	1,237	2,410	6	66	113	46	80	110	96	396	871	66
32S/13E– 8J1	C. T.	1	—	374	—	—	0	—	—	43	—	—	135	76	12
–12Q2	None*	10	560	623	674	0	2	10	83	161	188	47	58	76	46
–19L1	—	1	—	270	—	—	76	—	—	37	—	—	50	—	8
–19N1	C. T.	7	292	388	490	67	91	133	33	81	96	67	72	84	15
–20M3	—	2	470	506	642	133	138	142	77	81	86	82	83	85	28
–28E5	—	2	422	563	706	28	36	45	127	142	157	40	46	56	26
–30F1	C–15 30–40	3	1,900	1,984	2,032	23	27	33	192	337	437	641	674	598	83
–30H1	C. T.	8	426	465	618	104	141	163	79	89	97	63	59	65	21
–30K10	—	1	—	870	—	—	128	—	—	134	—	—	83	—	32
–30L2	C. T.	11	529	686	1,064	6	26	87	96	128	180	43	94	255	47
–30N1	0–15	4	531	848	896	2	4	8	153	243	366	100	118	132	33
–30Q4	—	1	—	733	—	—	116	—	—	156	—	—	94	—	39
–31B1	C. T.	2	796	833	872	90	98	107	183	196	210	91	96	99	46
–31B2	0–10*	1	—	840	—	—	34	—	—	164	—	—	45	—	56
–31B4	—	1	—	786	—	—	117	—	—	161	—	—	103	—	64
–31B6	—	1	—	760	—	—	121	—	—	169	—	—	103	—	42
–31B9	—	1	—	817	—	—	113	—	—	184	—	—	99	—	60
–31C1	—	4	1,468	2,360	2,871	0	2	4	36	284	410	523	896	1,101	96
–31J2	—	6	816	1,091	1,419	11	38	85	242	347	534	60	87	89	80
–31K1	—	1	—	1,447	—	—	9	—	—	494	—	—	124	—	132
–32A1	C. T.	14	240	536	724	33	103	172	21	134	194	35	61	76	31
–32C3	—	1	—	639	—	—	148	—	—	110	—	—	104	–	31
–32E2	—	1	—	656	—	—	0	—	—	142	—	—	87	—	31
–32H1	—	12	486	876	1,146	42	98	128	147	251	346	52	72	99	61
–32L18	—	1	—	1,144	—	—	65	—	—	288	—	—	123	—	86
–34Q1	—	1	—	615	—	—	195	—	—	22	—	—	106	—	20
32S/14E–15P1	None	1	—	898	—	—	12	—	—	268	—	—	67	—	88
Average for 30 wells				831			70			169			160		46
DEPTH 50'–180'															
32S/12E–24R2	0–70	4	458	529	581	10	18	29	76	98	132	64	99	141	35
32S/13E–11M1	C. T.	1	—	207	—	—	0	—	—	8	—	—	36	—	3
–12C4	C. T.	1	—	806	—	—	0	—	—	300	—	—	42	—	68
–14R2	—	2	618	847	878	0	3	5	73	76	80	53	64	66	65
–19J2	—	2	248	253	258	69	92	115	2	8	15	46	66	86	63
–19Q1	—	1	—	336	—	—	80	—	—	36	—	—	88	—	10
–20M1	—	1	—	337	—	—	20	—	—	14	—	—	92	—	8
–20N1	C. T.	1	—	630	—	—	118	—	—	136	—	—	76	—	40
–20N5	—	2	450	673	897	107	120	133	93	99	106	63	126	167	26
–22Q1	—	1	—	1,871	—	—	102	—	—	719	—	—	115	—	131
–24D1	—	1	—	960	—	—	0	—	—	308	—	—	71	—	60
–27D3	—	2	1,894	1,774	1,864	0	2	3	665	817	650	116	116	118	86
–28A4	C. T.*	1	—	1,885	—	—	1	—	—	673	—	—	97	—	15
–28E1	11–36*	4	660	687	892	14	19	25	167	169	177	61	55	60	53
–29D1	C. T.	4	481	583	642	0	2	8	112	137	149	27	32	34	45
–29D2	C. T.	2	466	472	478	116	116	116	82	89	77	63	72	81	19
–29D3	—	2	320	364	408	96	95	96	35	38	41	45	57	68	13
–29E1	0–25	5	583	588	610	5	85	144	112	134	160	35	66	72	34

TABLE 4

MINERAL CONSTITUENTS FROM SELECTED WELLS
ARROYO GRANDE BASIN
(Continued)

WELL	Seal (feet)	Number of analyses	Constituents in mg/l												
			TDS			NO_3			SO_4			Cl			Mg.
			Min.	Avg	Max.	Min.	Avg.	Max.	Min	Avg.	Max.	Min.	Avg.	Max.	Avg.
DEPTH 50' – 180' (Continued)															
32S/13E-29E2	0–26	4	445	572	668	0	46	100	105	122	136	44	84	91	36
-29E3	0–35	4	566	609	644	37	63	107	126	133	136	63	69	73	39
-29E5	—	1	—	568	—	—	156	—	—	84	—	—	68	—	28
-29F1	0–55*	4	684	756	814	8	55	96	127	141	151	62	80	100	40
-29G1	—*	10	460	613	706	9	40	111	131	143	163	32	48	80	43
-29P1	—	1	—	374	—	—	3	—	—	98	—	—	32	—	17
-30F2	0–70*	4	562	605	650	26	28	31	140	148	163	58	62	66	40
-30H2	C. T.	12	440	494	610	83	108	133	54	70	89	50	70	103	26
-30K4	—	1	—	595	—	—	6	—	—	100	—	—	36	—	36
-30K5	—	2	700	726	753	3	55	108	149	157	166	37	58	80	41
-30K6	—	5	546	728	904	6	50	65	123	149	165	39	117	184	46
-30N3	0–55*	4	561	762	804	0	0.4	1	231	241	250	41	58	73	56
-30P1	—	6	512	631	736	13	23	35	105	123	147	32	86	106	43
-30P2	—	1	—	765	—	—	115	—	—	209	—	—	102	—	50
-30R1	C. T.	13	470	587	792	62	94	128	67	114	150	57	73	86	31
-30R2	—*	2	554	591	629	131	154	176	106	114	122	67	7	76	27
-30R11	C. T.	1	—	580	—	—	120	—	—	121	—	—	61	—	21
-31F1	—	6	576	757	622	0	1	4	220	234	242	41	44	50	65
-31F2	0–130*	4	949	966	1,008	0	1	2	364	376	394	44	47	52	66
-32D2	—*	5	494	541	580	24	50	69	104	121	131	39	49	59	39
-32D3	—*	5	561	586	576	32	61	89	120	126	130	41	46	63	37
-32D9	C. T.	1	—	684	—	—	1	—	—	162	—	—	35	—	63
-32D10	C. T.	6	572	641	693	2	23	40	140	156	171	5	33	44	46
-32E13	—	1	—	656	—	—	0	—	—	178	—	—	32	—	63
-32L2	—	2	656	691	724	0	1	3	161	171	182	33	36	37	73
-32L5	C. T.	1	—	610	—	60	—	—	—	121	—	—	57	—	61
-32L6	C. T.	1	—	637	—	—	1	—	—	148	—	—	39	—	56
-32M1	C. T.	1	—	844	—	—	22	—	—	233	—	—	58	—	98
-33F1	—	2	821	876	934	6	26	46	231	259	288	35	44	53	90
-33K3	C. T.	1	—	1,524	—	—	62	—	—	510	—	—	105	—	126
32S/14E-17N2	—	1	—	726	—	—	15	—	—	102	—	—	60	—	78
12N/35W-28Q1	—	1	—	470	—	—	19	—	—	86	—	—	49	—	5
-29M1	—	1	—	988	—	—	0	—	—	320	—	—	74	—	72
-29N1	C. T.	2	1,264	1,369	1,474	0	1	1.9	399	440	480	106	109	112	99
-34G4	—	1	—	730	—	—	16	—	—	183	—	—	74	—	55
-35E1	—	1	—	786	—	—	7	—	—	161	—	—	69	—	56
-35E3	C. T.	1	—	715	—	—	5	—	—	197	—	—	71	—	59
-35H2	—	2	762	766	770	3	4	4	163	188	194	65	56	71	42
-35J1	C. T.	1	—	268	—	—	0	—	—	9	—	—	72	—	5
Average of 58 wells				711			45			180			54		47
DEPTH 100' – 565'															
32S/12E24R3	0–295	4	546	636	748	0	2	5	154	163	168	32	55	103	45
32S/13E-29G2	Yes*	4	510	539	661	4	19	27	146	155	165	32	41	46	52
-30F3	0–300*	4	600	633	586	0	1	1	176	182	188	43	58	73	41
-30N2	0–170*	4	1,020	1,047	1,069	0	0	1	483	487	496	48	52	55	70
-31F3	0–235*	4	1,060	1,091	1,160	0	1	2	481	515	545	48	51	57	74
-31F4	0–476*	4	548	579	628	0	0	1	118	127	144	75	82	89	38
12N/35W-32N1	0– 25*	1	—	245	—	—	27	—	—	9	—	—	67	—	8
-33B2	—	1	—	327	—	—	21	—	—	36	—	—	62	—	14
Average of 8 wells				549			9			209			61		46

C. T. – Cable tool well
* – Gravel packed well

to frequency -- nitrate, sulfate, magnesium, and chloride. The water is usually hard and often very hard.

Concentrations of TDS of the ground water extracted from Arroyo Grande alluvial deposits along the Creek range from about 500 to 2,900 mg/l and total hardness from about 400 to 1,300 mg/l.

Ground water extracted from a semiperched aquifer in the Paso Robles formation, lying beneath the older sand dune deposits, ranges from about 200 to 900 mg/l in TDS (excluding ground water samples from wells affected by saline deposits or by sea water). This water in the semiperched aquifer is softer, ranging from about 100 to 400 mg/l in total hardness.

Ground water extracted from Zone A (Table 2), which is in the Paso Robles formation, ranges from 250 to 1,000 mg/l in TDS (excluding ground water samples from wells affected by saline deposits or by sea water), and ranges from about 100 to 600 mg/l in total hardness. Ground water extracted from Zone B ranges from about 200 to 1,200 mg/l in TDS and from 50 to 650 mg/l in total hardness.

The wells with the highest nitrate concentrations are centered within a 6-square-mile area between Arroyo Grande, Oceano, and Grover City -- Sections 19, 20, and 29-33 of Township 32 South, Range 13 East, MDB&M -- where nitrate concentrations range as high as 195 mg/l. This area mostly underlies the permeable older sand dune deposits (DWR, October 1969).

Wells and springs showing concentrations of sulfate greater than 250 mg/l lie along low, marshy coastal areas and along Arroyo Grande, Los Berros, and Tar Spring Creeks and a small creek tributary to the latter.

Those with magnesium concentrations over 125 mg/l are few and widely scattered, and most of those with high chlorides are near the ocean.

Of 158 wells and springs in the subarea for which mineral analyses are available, 67 had average nitrate concentrations exceeding 45 mg/l; 43 had average sulfate concentrations exceeding 250 mg/l; 10 had average magnesium concentrations exceeding 125 mg/l; and 5 had average chloride concentrations exceeding 250 mg/l.

IMPORTED WATER

As previously stated, SLOCFCWCD has contracted for water from the State Water Project. Water quality objectives for project water are listed in Table 5.

TABLE 5

WATER QUALITY OBJECTIVES

STATE WATER PROJECT

Constituent	Milligrams per liter		
	Monthly average	Average per any 10-year period	Maximum
TDS	440	220	--
Total hardness	180	110	--
Chlorides	110	55	--
Sulfates	110	20	--
Boron	0.6	--	--
Fluoride	--	--	1.5
Lead	--	--	0.1
Selenium	--	--	0.05
Hexavalent chromium	--	--	0.05
Arsenic	--	--	0.05
Iron plus manganese	--	--	0.3
Magnesium	--	--	125
Copper	--	--	3
Zinc	--	--	15
Phenol	--	--	0.001

The proposed alignment of the California Aqueduct's Coastal Branch trends southward, passing midway between the City of Arroyo Grande and the Lopez Reservoir. This alignment will provide the area with a source of good quality water.

FACTORS INFLUENCING WATER QUALITY

Water quality is impaired by nature and man.

Impairment by Nature

Arroyo Grande Creek is degraded near the coast by the mixing of sea and fresh water due to tidal action that extends as far inland as 3,000 feet (DWR Bulletin No. 63-3). The ground water is impaired by percolating mixed fresh and saline surface water where streams and lagoons are inundated by sea water during high tides.

A small stream, Meadow Creek, flows southeast from Pismo Lake to Arroyo Grande Creek through marshes and lagoons. Its water is degraded by contact with and solution of minerals from marine saline deposits (DWR, October 1969).

Saline deposits occurring along tidal marshes, lagoons, and sloughs readily yield chloride and sulfate minerals to ground water.

Hardness is caused mainly by the solution of calcium and magnesium from the Jurassic rocks found in this area. Ground water migrating downward along the alluvium of Arroyo Grande Creek is recharged largely by runoff from the upper parts of the Valley. Having had more contact with calcium-magnesium-rich minerals, it is harder.

Ground water from beneath older dune sand deposits is consistently softer and of better quality than that from the alluvial deposits along Arroyo Grande Creek. Older sand dune deposits are extremely permeable and absorb much of the rain falling on them, thereby recharging the underlying aquifers with a relatively softer and less mineral concentrated water.

Ground water along the West Huasna fault zone shows sulfate concentrations of more than 250 mg/l. This is caused by the solution of minerals from the fractured rock zone and/or gases and mineralized juvenile water moving up along this fault zone.

Impairment by Man

Nitrate, particularly, and -- to a lesser degree sulfate and chloride -- are added to and increase the mineral constituents of the area's ground water by man's activity. Their adverse effects, however, can be minimized.

Nitrate impairment is caused by mineral contributions from (a) irrigation return water containing nitrogenous fertilizers and (b) domestic waste water. The latter consists of sewage discharges to individual septic tanks and leach fields and, in the past, from the no longer functioning Arroyo Grande Sewage Treatment Plant.

Wells in Recent alluvial deposits along Arroyo Grande and Los Berros Creeks and Tar Springs are extracting sulfate-impaired water which results, at least partially, from irrigation return. Chloride-impairment may result from water-softening wastes discharged to septic tanks.

APPENDIX A
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